circnets

O.2.2: Improving recycling of fishing gear with emerging technologies

A stakeholder analysis and technology assessment model

Interreg

Co-funded by the European Union

Northern Periphery and Arctic

CIRCNETS

GLOSSARY

Emerging technology: new or evolving innovations, characterized by rapid growth and the potential to disrupt industries and have major long-term economic and social impacts.

End-of-life fishing gear: Fishing gear and gear accessories (e.g. ropes, floats, sink weights and other attachments) that are no longer actively used by fishers. These gears are discarded.

Fishing port. A port that is mainly used by fishing vessels, (i.e., vessels that are used to catch fish or other living natural resources mainly commercially).

Pre-treatment methods: methods employed to end-of-life fishing gear before the treatment process (e.g., sorting, washing, drying, etc.).

SWOT analysis: strategic planning framework used to evaluate an organization's or project's Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T), helping to identify internal factors (S, W) and external factors (O, T) for better decision-making, goal setting, and strategy development.

TRL analysis: Technology Readiness Level (TRL) analysis is a systematic method to assess a technology's maturity, from basic research to proven, operational deployment. This tools guides investment and implementation by defining specific development stages.

ABREVIATIONS

CIRCNETS	Blue Circular Nets project
EC	End consumers
EOL	End-of-life
EPR	Extended producer responsibility
F/A I	Fishing/aquaculture industry
FFL	Fishing for Litter campaign
FGP	Fishing gear producers
LA	Local authorities
NGOs	Non-governmental organizations
PA	Port authorities
PM	Policy makers
R	Recyclers
RI	Research institutions
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis
TRL	Technology readiness level analysis
SP	Shredder producers
WMF	Waste management firms

INTRODUCTION

CONTEXT

Improperly managed EOL fishing gear poses significant environmental, social, and economic challenges, especially in regions where recovery technologies and good waste management practices are lacking. When EOL fishing gear are not collected, recycled, or safely disposed of, they often end up abandoned at sea or landfilled. Through extensive research and engagement with relevant stakeholders, the CIRCNETS project has identified the following **challenges and barriers in EOL fishing gear waste management**:

Logistics

The complexity of materials makes **transport and sorting difficult and labour-intensive. Limited collection points** and the need for **nearby pre-treatment facilities** further hinder effective management.

Materials

Skilled labour is required for sorting the materials fractions. **Contaminated materials are difficult to process.** These challenges significantly hinder effective recycling efforts.

Traceability

Manual tracking systems, inconsistent data sharing, and communication problems between value chain actors undermine transparency and reporting efficiency.

Economy

Recycled products often cost more than virgin plastic ones. Limited recycling facilities combined with **costly procedures** further reduce the economic potential of recycling EOL fishing gear.

Through webinars and workshops, stakeholders highlighted the following **needs**:

"Need for accurate mapping of waste volumes and composition"

"Segregation and pre-treatment are critical practices"

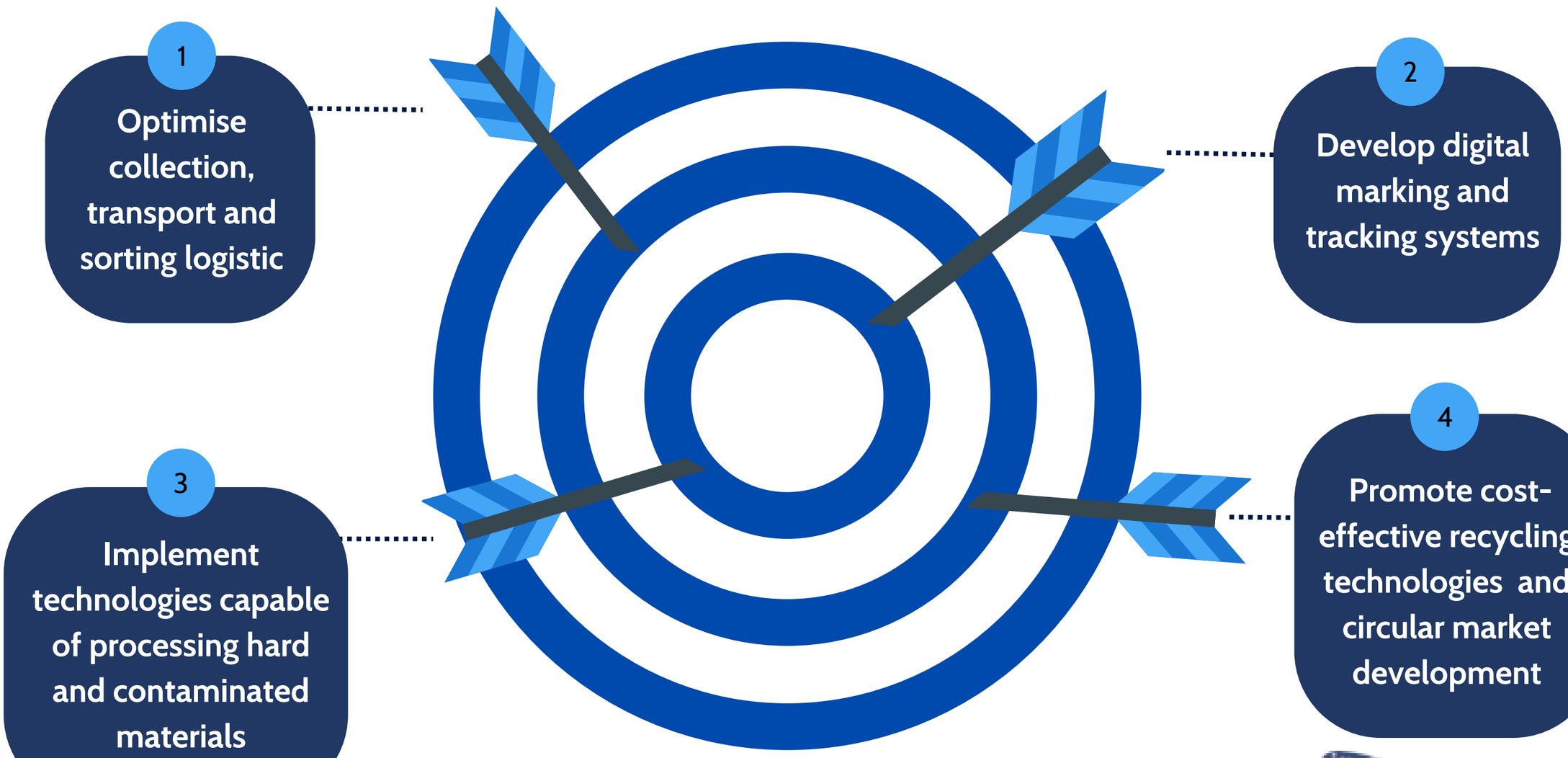
"Knowledge gaps and communication barriers need structured interventions"

"Some gear types are currently untouchable for recycling"

"Traceability challenges highlight the need for digital tools"

"There is market interest in recycled EOL fishing gear materials"

Therefore, based on these challenges, barriers and needs, the following **objectives** should be covered to assure the development of efficient EOL fishing gear waste management schemes:



EOL EMERGING TECHNOLOGY MODEL

To achieve these objectives, the Blue Circular Nets (CIRCNETS) project developed a **replicable EOL emerging technologies model**. The model enables a comprehensive analysis of promising technologies to improve EOL fishing gear waste management, assesses stakeholder involvement in their adoption, and produces tailored recommendations for each stakeholder group. It is intended for **actors across the fishing gear industry and fishing sector**, including manufacturers, recyclers, waste managers, fishers, port authorities, and policymakers.

POTENTIAL EMERGING TECHNOLOGIES

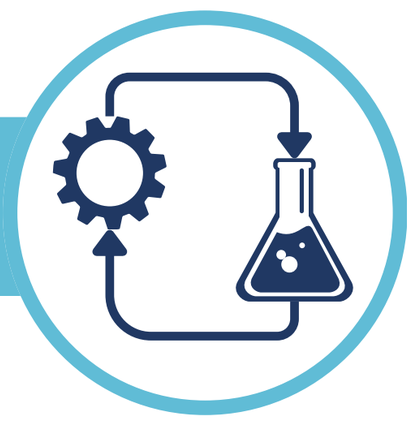
Based on the objectives previously mentioned, some of the following technologies could be explored under this model:

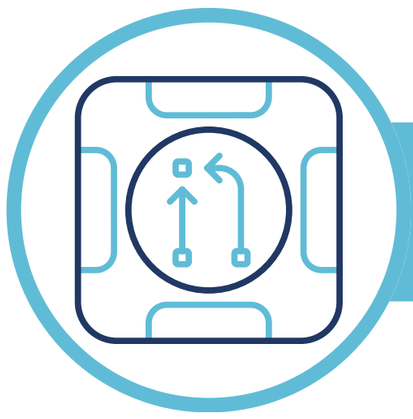
Mobile shredder unit

Digital Product Passport

Pyrolysis recycling

Hybrid recycling technologies





Industrial symbiosis platforms

EOL EMERGING TECHNOLOGIES MODEL

MODEL FRAMEWORK

Stakeholders

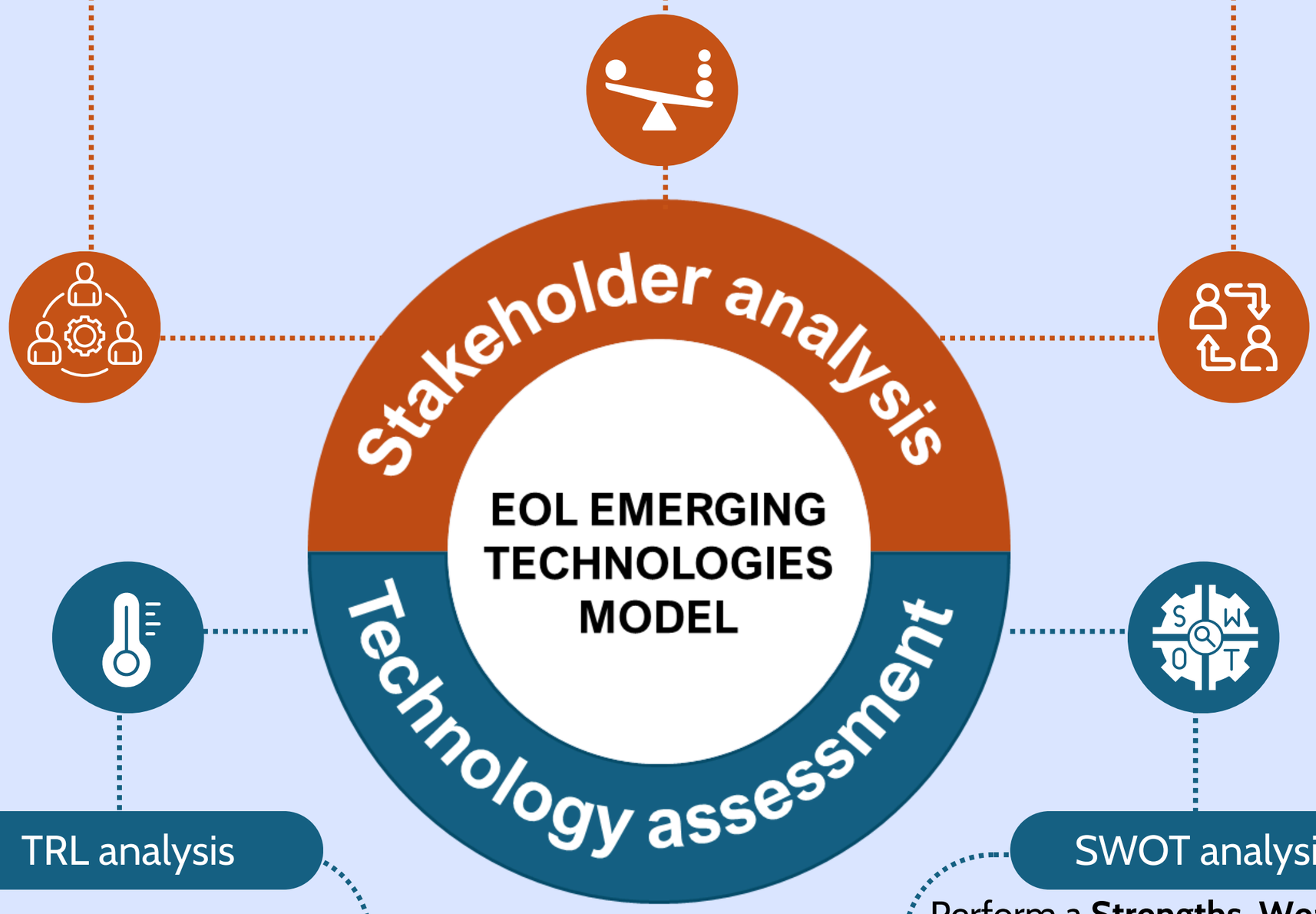
Identify
key stakeholders

Role/interest/power

Describe the **role, interest and power** of each stakeholder

Relationships & mapping

Identify **relationship between stakeholders** and map them in a **power/interest grid**



TRL analysis

Perform a **Technology Readiness Level (TRL) analysis**

SWOT analysis

Perform a **Strengths, Weaknesses, Opportunities and Threads (SWOT) analysis**

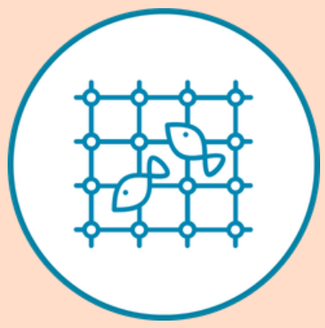
Recommended actions per stakeholder to promote the implementation of a given technology

MODEL FRAMEWORK STEP BY STEP

STAKEHOLDER ANALYSIS

Stakeholders

Identify key stakeholders involved in the implementation of a given technology. **Stakeholder categories** to consider:



Fishing/aquaculture gear producers

Fishing/aquaculture industry

Port authorities

Local authorities

NGOs

Recyclers

Waste management firms

Policy makers

Research institutions

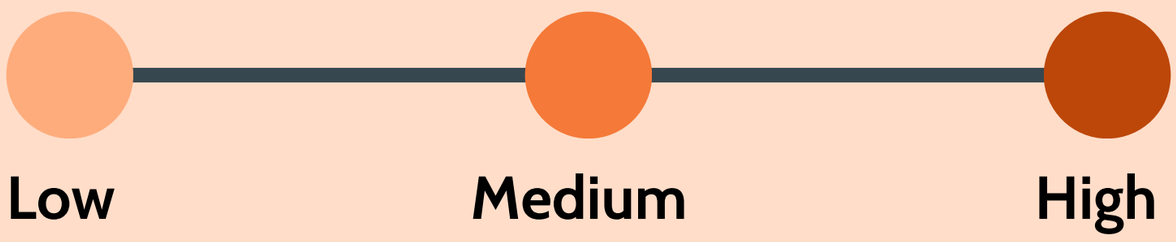
Technology developers

End consumers

STAKEHOLDER ANALYSIS

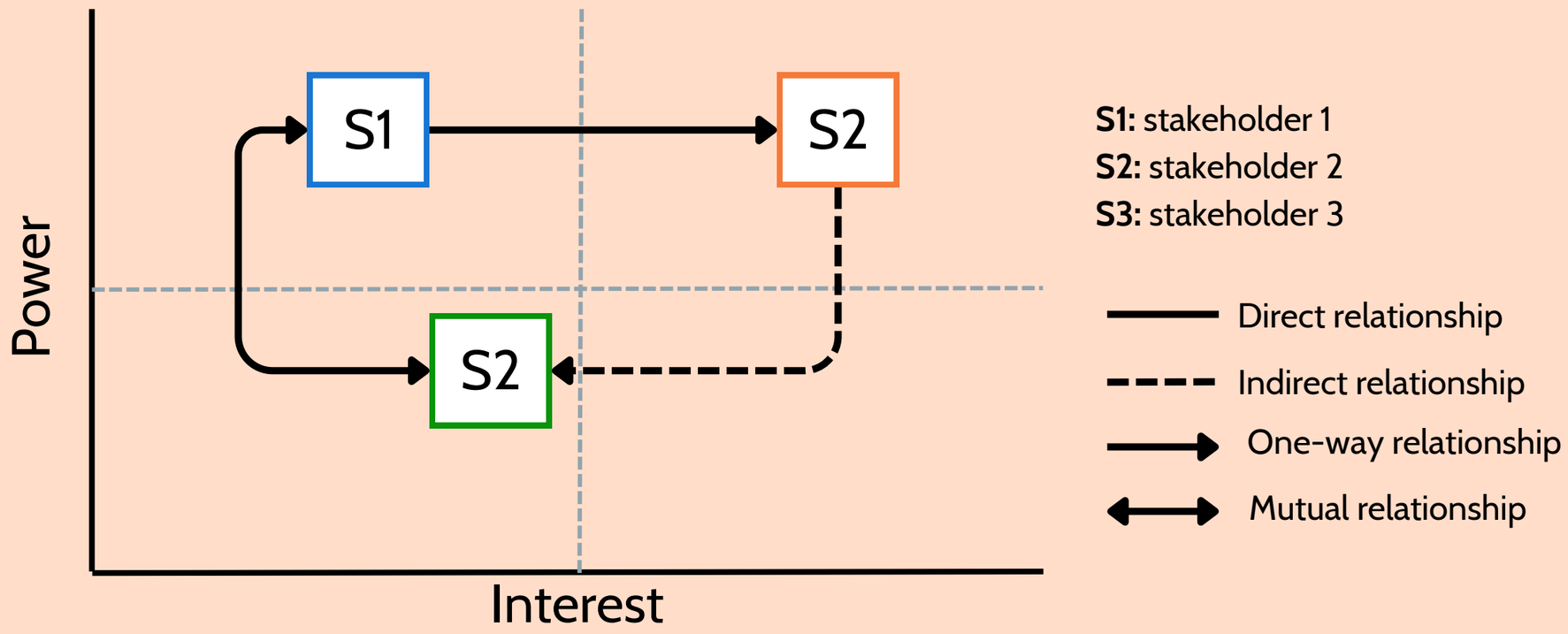
Role/interest/power

Describe the role, interest and power of each stakeholder to implement a given technology. Interest and power can be assessed through a **low to high scale.**



Relationships and mapping

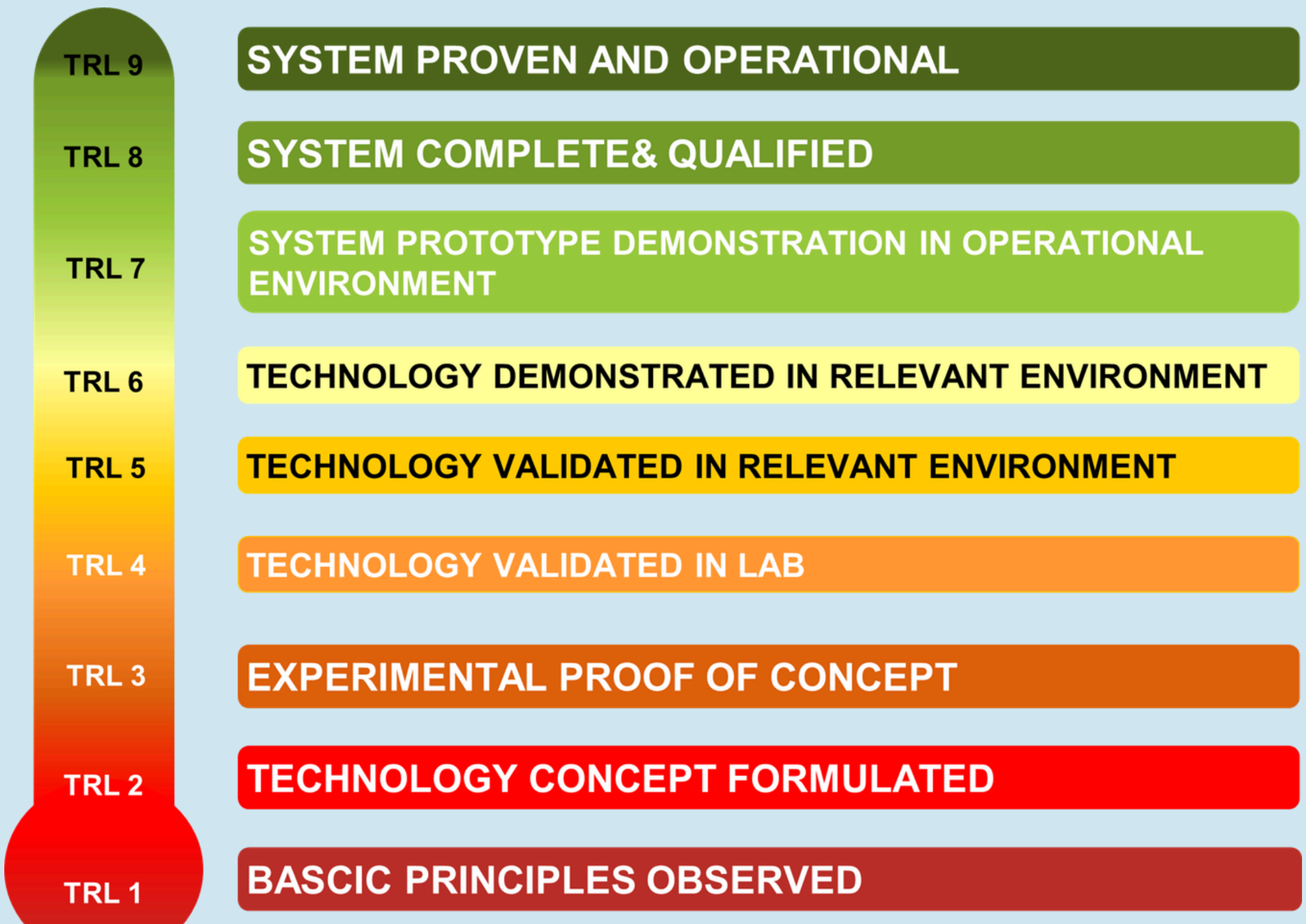
Identify **relationship between stakeholders** that could influence the implementation of the technology. Map the stakeholders in a **power/interest grid** to visualize where do they fall within these dimensions. **Optional:** visualize the relationships between the stakeholders in the map.



TECHNOLOGY ASSESSMENT

TRL analysis

A Technology readiness level (TRL) analysis describes the development stage of a technology before its commercialization. TRL levels range from basic theoretical concept at level 1 to a fully operational system at level 9 [1]. Performing a TRL analysis allows us to determine the **maturity of the technology** and what is needed to achieve full commercialization and implementation.



For more information on TRL analysis: https://euro-funding.com/en/blog/what-is-the-technology-maturity-scale-trl/

TECHNOLOGY ASSESSMENT

SWOT analysis

A SWOT analysis is a strategic tool used for context analysis by assessing the Strengths, Weaknesses, Opportunities, and Threats of an organization, region, or sector. It evaluates internal factors alongside the external opportunities and threats present in the surrounding environment [2]. It helps identify attributes that may enable or hinder the implementation of a given technology.

	Helpful to achieve implementation	**Harmful** to achieve implementation
Internal origin Technology attributes	**Strengths**	**Weaknesses**
External origin Environmental attributes	**Opportunities**	**Threats**

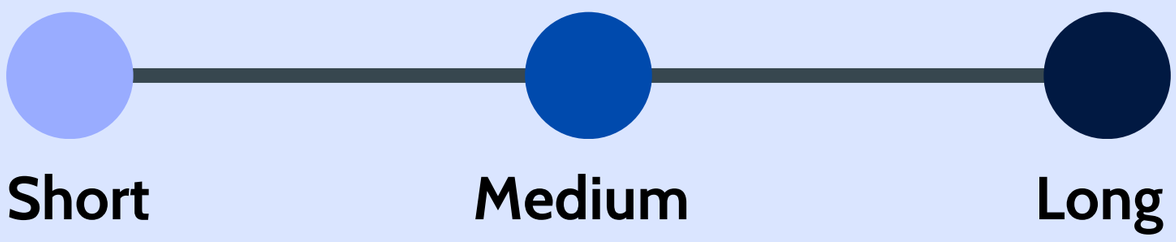
For more information on SWOT analysis: https://euro-funding.com/en/blog/what-is-the-technology-maturity-scale-trl/

RECOMMENDED ACTIONS

The stakeholder analysis identifies the key actors involved in the technology implementation and their influence, while the technology assessment highlights factors that enable or hinder adoption. These insights are then used to define **recommended actions for each stakeholder** to support the implementation of the technology. These recommended actions should cover the following aspects:

Stakeholder-specificity	Actions should be tailored to stakeholder roles, power, interests and relationships
Regulatory alignment	Actions should comply with EPR directive and other EU or national regulations
Technology fit	Actions should consider the TRL level and be adapted to materials and operational benefits or constraints
Economy feasibility	Actions should reflect operational or investment costs
Operational integration	Actions should be aligned with existing practices
Capacity building	Actions should promote training and skills development
Environmental and safety safeguard	Actions should ensure environmental impact mitigation

In addition, each action should be assigned a **timeframe** that reflects the execution urgency:



EXAMPLE: MOBILE SHREDDER UNIT

EXAMPLE: MOBILE SHREDDER UNIT

Here is presented an example of how the EOL emerging technologies model could be applied for a real technology: **a mobile shredder unit for processing EOL fishing gear waste.**

A mobile shredder unit is a portable shredder, usually mounted on a truck or trailer, designed to reduce materials into smaller pieces directly at the point of generation. They can be used to recycle wood waste, bulky commercial and household waste, and to process materials such as car bodies, tires, aluminium profiles, and other light metals [3]

Mobile shredders present the following characteristics [4 and 5]:

- **Mobility:** mobile shredders can be transported in trucks directly to the waste locations.
- **Shredding capacity:** designed for large volumes, mobile shredders can handle 4 to30 tonnes per hour.
- **Robust materials:** they are built with durable materials such as Hardox steel blades for their continuous and heavy-duty operations.
- **Automated operations:** Equipped with features like automated bin lifters, feed conveyors, and remote controls.
- **Versatile use:** Suitable for shredding a wide range of materials such as wood, plastics, medical waste, and metals.

Considering these characteristics, mobile shredders could be used to process EOL fishing gear; however, to date they haven't been fully implemented in collection and recycling systems. Only one pilot has been done in Ireland [6].

STAKEHOLDER ANALYSIS

The following table presents the stakeholder analysis for the implementation of mobile shredder units for EOL fishing gear processing:

Stakeholder	Role	Interest	Power	Realationships
Policy makers (PM)	Develop and revise EPR regulations; create incentives or funding mechanisms supporting mobile shredding technologies.	Medium-High	High	Influence local authorities, waste management firms, fishing gear producers and recyclers through legislation and funding; informed by research institutions and NGOs; directly impacts fishing and gear producers through legislation.
Fishing gear producers (FGP)	Design, production of fishing gear; responsible under EPR for financing collection and treatment through PROs; influence material choices for the design of fishing gear.	Medium-High	Medium	Impacted by EPR obligations; collaborates with recyclers and researchers on material compatibility; interacts with BIM to set up collection and recycling schemes; influence fishing industry via product design and pricing.
Fishing/aquaculture industry (F/A I)	Generates EOL fishing gear waste; participate in collection schemes.	Medium-High	Low-Medium	Collaborates with port authorities in the implementation of good waste management practices; influenced by policy makers through future EPR obligations; directly linked to fishing gear producers through product purchasing.
Port authorities (PA)	Manage waste logistics at ports.	Medium	Medium	Coordinates fishermen practices. Supervised by local authorities. Interacts with recyclers and waste operators to send waste fractions. Operate under environmental and waste regulations.
Local authorities (LA)	Responsible for local waste management planning and implementation.	Medium	Medium-High	Collaborate with port authorities waste management firms, recyclers, and NGOs to implement efficient waste management schemes; link between national policy and local implementation.

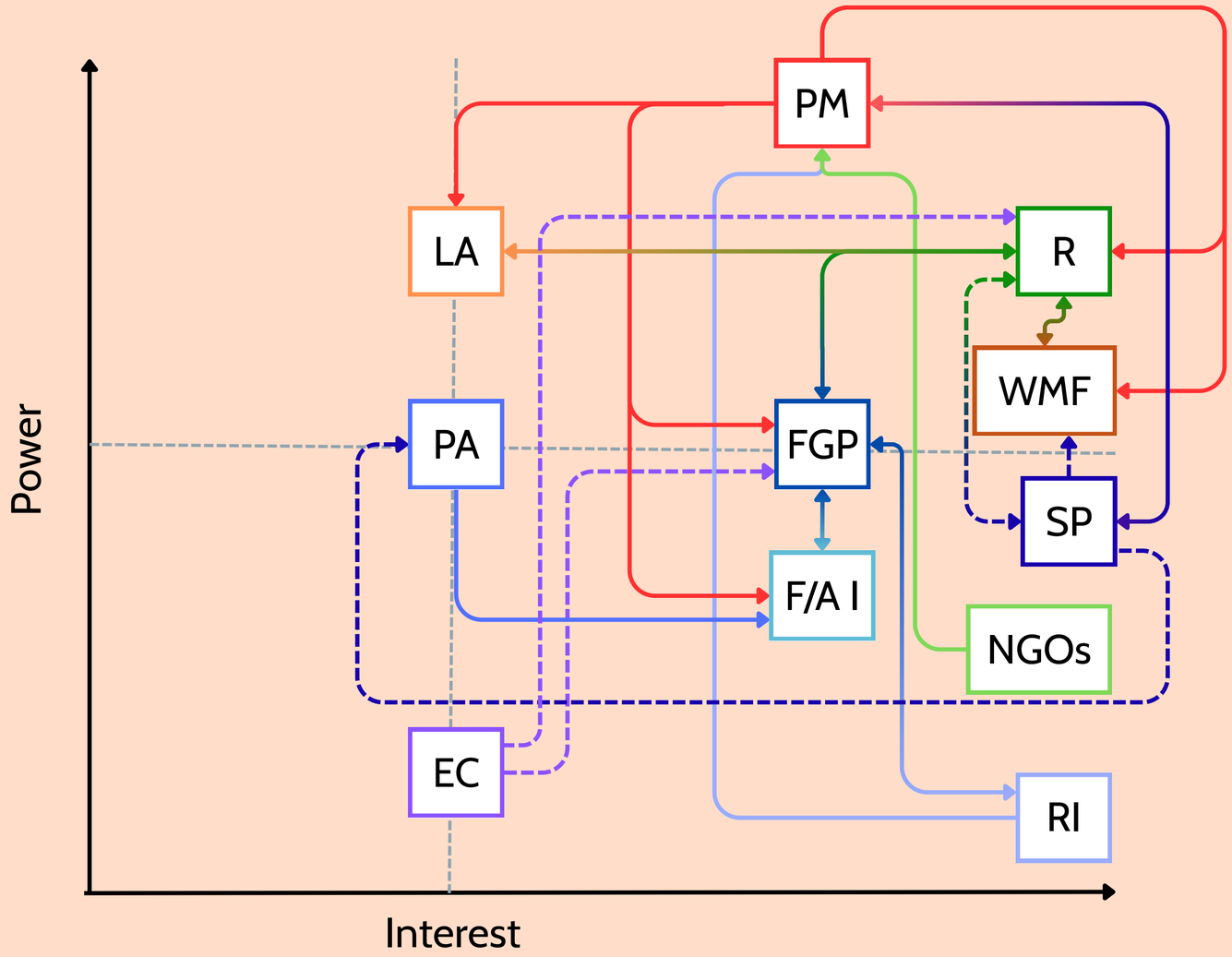
STAKEHOLDER ANALYSIS

Stakeholder analysis table continuation:

Stakeholder	Role	Interest	Power	Realationships
Waste management firms (WMF)	Collects, transports, stores, and manages EOL fishing gear waste.	High	Medium	Work closely with port authorities, local authorities and recyclers to develop fishing gear waste management schemes; interact with fishing communities during collection.
Non-Governmental Organizations (NGOs)	Promotes environmental protection and circular economy principles.	High	Low-Medium	Collaborate with local authorities, waste management firms, and fishing communities to promote sustainable practices; exert pressure on manufacturers and policy makers to implement sustainable technologies.
Research institutions (RI)	Provides scientific and technical expertise; evaluates performance and environmental impacts of mobile shredders; supports innovation and optimization of recycling technologies; generate evidence to inform policy makers.	High	Low-Medium	Advise policy makers; collaborates with recyclers, waste management firms, and technology providers to support pilot projects and data collection for EPR implementation.
Shredder producers (SP)	Technology provider and manufacturer of mobile shredders.	High	Low-Medium	Commercial relationship with local authorities; indirect relationship with waste management firms, recyclers, and port authorities through shredder performance and suitability.
Recycling plants (R)	Receives shredded fishing gear; processes it into recycled feedstock and new products.	High	Medium-High	Depends on waste management firms, port authorities, and local authorities for material supply; influences shredder configuration; linked to manufacturers and end consumers through recycled products.
End consumers (EC)	Creates market demand for recycled products.	Medium	Low	Indirectly influences recyclers and manufacturers through demand for recycled products; supports long-term economic viability of EPR schemes.

STAKEHOLDER ANALYSIS

As a result of the stakeholder analysis, stakeholders were mapped on an interest–power grid, and some key relationships between them were visualized. This approach helps refine recommendations by considering the stakeholder's influence on the implementation of mobile shredder units to process EOL fishing gear waste.

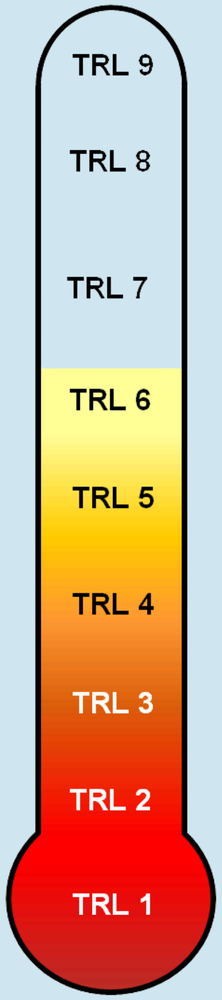


Observations

- **Medium to high interest across stakeholders can facilitate technology implementation** by promoting engagement, collaboration, and participation in pilots and operational changes.
- **Differences in power can create imbalances in decision-making, resource allocation, and responsibility**.
- Stakeholders with **high power and interest** (e.g., policy makers) are **key for the implementation** of mobile shredders.
- Stakeholders with **medium interest** (e.g., Port authorities, local authorities and end consumers), should be **incentivized to promote the implementation** of mobile shredders.
- Most of the stakeholders **have mutual relationships,** showing **high interconnection and potential collaborations.**
- **Policy makers** have a **strong influence** due to **high power** and **one-way direct relationships.**
- **End consumers** have a **weak influence** due to **low power** and **indirect relationships.**

TECHNOLOGY ASSESSMENT

Considering the definitions of the TRL analysis levels [7], the mobile shredder characteristics [3,4 and 5] and pilot results from Ireland[6], this technology can be classified under: **TRL6 – Technology demonstrated in relevant environment.**



Engineering-scale prototype demonstrated	Mobile shredders are a **full-scale, engineer-grade technology** that present sufficient technical requirements (i.e., shredding unit, stand-alone generator, mobility and transport systems, loading and discharge mechanisms) to be adapted for the proper shedding of EOL fishing gear. These characteristics **demonstrate that mobile shredder can operate at a pilot/engineering scale**, rather than earlier laboratory-based levels.
Tested in a relevant operational environment	A mobile shredder was **tested and used** to process real EOL fishing and aquaculture gear collected in Ireland. It was deployed directly in Irish fishing ports, which closely **represent a real-world operational environment.**
Pilot-scale results and performance evidence	The pilot recycling project conducted in 2012 **processed 187 metric tonnes fishing gear**, producing **74 tonnes of marketable polyethylene feedstock [6]**. These results confirms that the shredded output meets recycling requirements and are **consistent with the performance data expected at TRL 6** to reduce engineering and operational uncertainty.
Demonstrated scalability and operational Learning	The shredder's mobility allows it to be deployed at fishing ports or collection points for EOL fishing gear. In this way, it can be tested the following logistical and operational conditions: • **Refinement of operational practices.** • **Understanding of set-up time, logistics, and coordination needs.** • **Insight into cost and deployment requirements.** This reflects the TRL 6 objective of **learning from pilot deployment** to inform future system design and scaling.
Cost and risk reduction characteristics	Previous pilots with mobile shredders can be used to assess **deployment costs, operational feasibility and compatibility with EOL fishing gear and existing waste management systems.**

TECHNOLOGY ASSESSMENT

Based on the general aspects of mobile shredder units and its characteristics [3,4 and 5], the following **SWOT analysis** was conducted focused on the implementation of this technology to process EOL fishing gear waste:

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• **High volume reduction:** up to 75%. • **High flexibility and mobility:** allowing on-site processing at collection points. • **Ability to process a wide range of waste materials:** including plastic from fishing gear waste (i.e., nets, ropes, floats, fish boxes, etc). • **Flexible loading and discharge options:** enables adaptation to different port infrastructures. • **Reduces processing time** by avoiding moving the waste to processing facilities. • **Supports economical recycling:** enabling shredded material to be transported to recycling plants for further processing.	• **Diesel-powered engine:** compared to electric stationary shredders, reliance on diesel could lower energy efficiency and increase operational costs. • **Noise, heat, and air emissions:** may limit operating hours or acceptance in port environments. • **Material quality:** processing strong/entangled materials such as ropes and nets may require cutting or manual intervention before shredding. • **Long-term usage:** mobile shredders could have limitations that make them not suitable for a long-term stationary solution, making it less efficient if waste volumes are consistently high at a single location.	• **Alignment with circular economy principles:** enabling EOL fishing gear to be treated as a recyclable resource. • **Strong fit with decentralised collection models:** relevant where centralised collection is not practical. • **Potential integration with advanced technologies:** IoT monitoring, automation, or hybrid diesel–electric power system. • **Support for local recycling value chains:** reducing reliance on exporting waste. • **Scalability through shared or rotating deployment:** allowing one unit to serve multiple ports or regions. • **Demonstrated success in pilot projects:** showing feasibility for processing significant volumes of fishing gear waste.	• **High capital investment costs:** may limit adoption by smaller operators or local authorities without subsidies. • **Competition with alternative waste treatment options:** incineration or energy recovery solutions. • **Operational efficiency depends on fishing gear waste quality.** • **Economic uncertainty:** due to fluctuating recycled material markets, the financial viability could be affected. • **Environmental and social constraints:** including emission and community acceptance in port areas. • **Risk of underutilisation:** if waste volumes are lower than expected or collection systems are not well coordinated.

RECOMMENDED ACTIONS

Based on the stakeholder analysis and the technology assessment, the following recommended actions are defined to promote the implementation of the mobile shredder units for EOL fishing gear waste processing:

Staekholder	Short term (0-2 years)	Medium term (2-5 years)	Long terms (+5 years)
Policy makers	Support pilot projects through funding and regulatory flexibility.	Integrate mobile shredding as an approved waste management practice within EPR regulations.	Establish stable EPR fee structures and long-term incentives for decentralised treatment technologies.
Fishing gear producers	Engage in pilots and provide feedback on material compatibility.	Contribute financially through PROs	Adapt gear design to improve the shredding capacity and recyclability.
Fishing/aquaculture industry	Participate in collection schemes and apply basic pre-treatment practices.	Align waste practices with EPR requirements and scheduled shredder visits.	Embed EOL gear management as a recurring operational practice.
Port authorities	Provide access, space, and logistical support for pilot deployments.	Integrate mobile shredding into port waste management plans.	Invest in infrastructure adaptations to support regular mobile shredder use.
Local authorities	Facilitate permits, coordination, and reporting of waste data..	Integrate mobile shredding into local waste management strategies.	Optimise regional deployment based on performance and compliance data.

RECOMMENDED ACTIONS

Staekholder	Short term (0-2 years)	Medium term (2-5 years)	Long terms (+5 years)
Waste management firms	Support collection, handling, and transport based on pilot results.	Develop a combined collection and on-site shredding system for EOL fishing gear	Invest in complementary services or equipment to maximise shredder utilisation.
Recycling plants	Define technical requirements for shredded output quality.	Adapt processes to handle shredded fishing gear waste.	Expand recycling capacity and product markets for recycled fishing gear plastics.
Shredder producers	Provide technical support during pilot deployments.	Refine shredder's design based on operational feedback.	Develop upgraded or more energy-efficient models aligned with EPR demand.
NGOs	Raise awareness of pilots and environmental benefits.	Support stakeholder engagement and transparency for the implementation of mobile shredders under EPR schemes .	Advocate for long-term adoption of circular and decentralised solutions.
Research institutions	Monitor and assess technical, environmental, and economic performance.	Generate evidence to support optimisation and policy decisions on the implementation of mobile shredders.	Support innovation to move the technology beyond TRL 6.
End consumers	Increase awareness of recycled fishing gear products.	Support demand for recycled-content products.	Reinforce long-term market viability through sustained demand.

CONCLUSION & BENEFITS

The EOL Emerging Technologies Model provides a structured and practical framework to assess and support the implementation of emerging technologies for EOL fishing gear waste management. By combining stakeholder analysis, TRL assessment, and SWOT analysis, the model helps translate technical innovation into coordinated, real-world actions across the value chain.

The **key benefits** of applying this model are:

Improved value chain efficiency

Identifies bottlenecks and aligns technologies with collection, processing, and recycling needs.

Promotes material circularity

Supports recovery of EOL fishing gear as a secondary resource and enables circular product pathways.

Better decision-making

Provides evidence-based insights on technology maturity, risks, and implementation readiness.

Faster technology adoption

Defines time-framed and stakeholder-specific actions that reduce uncertainty and accelerate uptake.

Stronger policy & regulation

Informs effective EPR design and regulatory support aligned with real operational conditions.

New market opportunities

Supports development of markets for recycled fishing gear materials and circular products.

Enhanced stakeholder collaboration

Clarifies roles and relationships, supporting coordinated action across public and private actors.

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REFERENCES

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circnets

Improving the management of end-of-life fishing gear

Blue Circular Nets (CIRCNETS) supports collection, treatment and recycling of fishing gear, so that these end-of-life nets are disposed appropriately, and they will not end up in seas and degrade the marine environment.

interreg-npa.eu/projects/circnets/

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